

PATENT APPLICATION  
OF  
DAVID CALLEY AND HARRISON KNOWLER  
FOR  
WIND TURBINE CONTROLLER

Sheets of drawings: 6

Agent:  
John VandenBosche  
17405 NE 131 Street  
Redmond, WA 98052

## Wind Turbine Controller

### Field of the Invention

The invention relates to the field of wind turbine generators. Specifically, the invention relates to a controller for permanent magnet, direct current wind turbines.

### 5 Background of the Invention

Wind turbines have gained widespread use for electricity generation in recent years and a growing market is small-scale turbines for battery charging or residential use. Small-scale wind turbines typically utilize a permanent magnet alternator to convert rotational power in the turbine's rotor into useful electrical power. Permanent magnet  
10 alternators have many advantages that cause them to be well suited for use in a wind turbine. Their simplicity, durability, and efficiency are excellent for wind turbine applications.

Permanent magnet alternators, however, also have several weaknesses that must be overcome when designing a wind turbine generator. The first problem is that the  
15 alternator tends to lock into a preferred tooth-magnet position and a relatively high wind gust may be needed to initiate rotation of the alternator. Another problem with permanent magnet alternators is that their power output increases linearly with rotational speed whereas, for a wind turbine to maintain optimum aerodynamic efficiency, the alternator's power should increase with the cube of the rotational speed. Designing a  
20 wind turbine to operate at maximum efficiency at a design wind speed with sub-optimum efficiency at all other wind speeds typically gets around this problem. The next problem is that when an alternator is directly coupled to a wind turbine rotor, its output is at a low

voltage unless a large number of turns of very fine wire are used in constructing the windings. Using such fine wire results in high electrical resistance and low efficiency.

A permanent magnet alternator typically includes three sets of windings in the stator and the output of the alternator is three phase power with varying voltage and frequency. In order to use the output power for battery charging or other useful purposes, the output is typically rectified to direct current. The rectification is most commonly achieved with a diode bridge as shown in Figure 3. The circuit shown in Figure 3 will provide a direct current output, but the voltage still varies. A voltage regulating controller is typically utilized for battery charging and other applications.

The prior art uses of permanent magnet alternators do not allow for aerodynamic stall of the wind turbine blades. This is because the speed of the rotor continues to increase as long as the wind speed increases. To achieve power regulation with a permanent alternator wind turbine, it is typical to provide a tail vane that furls the rotor out of the wind, or to design some other power limiting scheme built into the mechanical and aerodynamic design of the wind turbine. However, it would be desirable to have a permanent alternator that could provide increasing torque loads above a certain speed or power level in order to slow the wind turbine's rotor and induce aerodynamic stall.

Another problem with typical prior art uses of permanent alternators for wind turbines is that the output voltage was relatively low. If a user wishes to invert the output power for use in an alternating current application, it is necessary to first boost the output voltage to a high voltage before putting the power through the inverter. The voltage boost is typically built into the inverter and increases the cost and complexity of the